FHWA/IN/JTRP-2007/26

Final Report

AUTOMATING MATERIAL DELIVERY RECORDS

Joo Hyoung Lee
Bob McCullouch

June 2008

INDOT Research

TECHNICAL *Summary*

Technology Transfer and Project Implementation Information

TRB Subject Code: 33-1 Construction Control *June 2008*
Publication No.FHWA/IN/JTRP-2007/26, SPR-3083 *Draft Final Report*

Automating Material Delivery Records

Introduction

Every material delivery to an INDOT project requires a delivery ticket. Typically, starting with the material supplier and going through the process of delivery, material records are generated, transferred, approved, recorded and saved. These records are used to track what goes into a project, pay for the material, trucking, and the contractor. These records are also used to close out a project and they become a part of the final construction record for the project.

The current process at INDOT utilizes paper forms. Often this process becomes rather burdensome when reconciling with various parties. Daily compiling the material records becomes a time consuming effort because it is a manual process and the data requires multiple levels of review. Therefore, an automated process that incorporates the use of automatic identification technologies could significantly alter and benefit the material delivery process saving much time while improving the data quality.

If material delivery data can be automated from inception through finality, accuracy, reliability, and productivity of those involved can improve. Technically, an automated system would make the transfer and compilation of this information more accurate and efficient. Another outcome is periodic summaries of the materials can be generated automatically. This project is evaluated how to automate this process.

Findings

One result determined what hardware options are available for future system development. The project conducted numerous meetings with stakeholders that included INDOT materials and test staff, and pavement and material producers. Also, two surveys were conducted in an effort to collect inputs from other state transportation agencies and material producers. These two surveys provided information on new trends and technologies in materials industry, current systems used by state agencies, contractors, and material suppliers, and their willingness modify the current delivery process through the use of bar codes.

This project investigated current automatic identification technologies used in the material delivery industry, and in turn provided several alternatives and concerns toward the development of automatic materials delivery system at INDOT. The project identified several technical, managerial options to be considered to develop automated materials delivery records. Apparently, depending on the options chosen, cost and methods for actual development may vary due to the variance of required hardware and software.

Using bar codes on delivery tickets is recommended and acceptable to the majority of INDOT stakeholders. However, there is some resistance among some of the aggregate suppliers. Because some suppliers will not be able to produce these types of delivery tickets, a paper based ticket will continue to be accepted. Additionally, it is recommended that an on-line tracking system can provide a significant upgrade and improvement to the current material record system. The on-line application would be interfaced into SiteManager. By establishing an on-line system and encouraging bar coded delivery tickets, an automated delivery process for materials can be initiated.

Implementation

Actual development of an automated materials delivery records system needs support and approval from the following groups at INDOT: Materials and Tests, Construction, Operations, and BITS to make this system a standardized means to manage materials delivery data and interface with SiteManager. INDOT's industry partners are interested in moving ahead with this capability. It is recommended that a task group consisting of appropriate INDOT personnel, a representative sample of material suppliers and contractors be formed and make plans to develop a consensus on a material delivery ticket that can be produced and used on INDOT projects. Implementation assistance will be available by contacting the principal investigators as noted below.

Contacts

For more information:

Dr. Bob McCullouch
Co-Principal Investigator
School of Civil Engineering
Purdue University
West Lafayette IN 47907
Phone: (765) 494-0643
E-mail: bgm@ecn.purdue.edu

Prof. Joo Hyoung (Jay) Lee
Co-Principal Investigator
School of Technology
Purdue University-Calumet Campus
Hammond IN 46323
Phone: 219-989-3225
E-mail: leej@calumet.purdue.edu

Indiana Department of Transportation
Division of Research
1205 Montgomery Street
P.O. Box 2279
West Lafayette, IN 47906
Phone: (765) 463-1521
Fax: (765) 497-1665

Purdue University
Joint Transportation Research Program
School of Civil Engineering
West Lafayette, IN 47907-1284
Phone: (765) 494-9310
Fax: (765) 496-7996
E-mail: jtrp@ecn.purdue.edu
http://www.purdue.edu/jtrp

Final Report

FHWA/IN/JTRP-2007/26

AUTOMATING MATERIAL DELIVERY RECORDS

By

Joo Hyoung (Jay) Lee, Ph.D., P.E.
Assistant Professor
Department of Construction Management &
Engineering Technologies
School of Technology
Purdue University Calumet

and

Bob McCullouch, Ph.D., P.E.
Information Technology Administrator/
Research Scientist
School of Civil Engineering
Purdue University
West Lafayette

Joint Transportation Research Program
Project No. C-36-73HH
File No. 3-4-34
SPR- 3083

Conducted in Cooperation with the
Indiana Department of Transportation
Federal Highway of Administration
U.S. Department of Transportation

Purdue University
West Lafayette, Indiana
June 2008

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/IN/JTRP-2007/26		

4. Title and Subtitle	5. Report Date
Automating Material Delivery Records	June 2008
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Joo Huoung Lee and Bob McCullouch	FHWA/IN/JTRP-2007/26

9. Performing Organization Name and Address	10. Work Unit No.
Joint Transportation Research Program 1284 Civil Engineering Building Purdue University West Lafayette, IN 47907-1284	
	11. Contract or Grant No. SPR-3083

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Indiana Department of Transportation State Office Building 100 North Senate Avenue Indianapolis, IN 46204	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the Indiana Department of Transportation and Federal Highway Administration.

16. Abstract

This project investigated methods on automating field data collection of materials. The method chosen and investigated was bar codes. The automated process requires material suppliers to produce delivery forms that can be recorded and tracked using bar codes. The report describes a system configuration that shows a conceptual process to electronically transfer materials information between the material supplier, trucking company, INDOT personnel and contractor. Other activities reported include survey results from other state transportation agencies, material suppliers, and concrete paving companies. Also, investigated was how to interface with SiteManager software. Recommendations described hardware options for using bar codes and industry reaction to using bar coded delivery tickets.

17. Key Words	18. Distribution Statement
materials delivery, automatic identification system, bar code, delivery tickets	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	60	

Form DOT F 1700.7 (8-69)

Table of Contents

Introduction 1

Work Activities 2

Literature Review 3

- Automatic Identification and Data Capture (AIDC) 3
- Material Delivery Procedure 7
- Case Studies 11

Inputs from State Transportation Agencies 21

- Overview 21
- Survey Results and Review 22

Inputs from Pavement and Aggregate Producers 26

- Survey Aggregate Producers 26
- Concrete Pavement 31
- Concrete Batch Plant Producer 32
- Review of Rexcon Ticket 33

System Configuration 35

- System Overview 35
- Prototype Ticket Using Bar Codes 36

Interface with SiteManager 39

Development Costs 42

Conclusions 43

Appendices

- Appendix A. State Transportation Agencies Survey Questions a-1
- Appendix B. Pavement and Aggregate Business Sectors Survey Questions a-2
- Appendix C. SAC Meeting Minutes a-3
- Appendix D. Other Meetings a-7

List of Figures

Figure 1 Example of Bar Codes 4
Figure 2 Pen-based Bar Code Scanner 5
Figure 3 PDA Bar Code Scanner 6
Figure 4 Typical Materials Delivery Procedure 9
Figure 5 Schematic Diagram of Automated Materials Delivery Procedure 10
Figure 6 20/20 Delivery® Delivery Process 14
Figure 7 Sample Report 15
Figure 8 Sample Customer Information 16
Figure 9 Sample Manifest Report 17
Figure 10 Result of Survey Question 1 22
Figure 11 Result of Survey Question 9 25
Figure 12 Material Information from E&B Paving 32
Figure 13 Form SM 652 by INDOT 33
Figure 14 Sample Rexcon Ticket 34
Figure 15 Automated materials Delivery Procedure 36
Figure 16 Scan Form (Pocket PC Version) 37
Figure 17 Prototype Delivery Ticket Using Bar Codes 38

List of Tables

Table 1 Proposed Automated Materials Delivery Procedure 35
Table 2 Comparison of Equipment Options and Costs..... 42

Introduction

Every material delivery to an INDOT project requires a delivery ticket. This information is used to pay the contractor and saved to the project record. Typically, starting with the material supplier and going through the process of delivery, material records are generated, transferred, approved, recorded and saved. These records are used to track what goes into a project, pay the material supplier, trucking, and the contractor. These records are also used to close out a project and they become a part of the final construction record for the project.

The current process in INDOT utilizes paper forms throughout. Often this process becomes rather burdensome when reconciling with various parties. Daily compiling the material records becomes a time consuming effort because it is a manual process and the data requires multiple levels of review. In fact, previous studies discovered that on the average between 30%-50% of field supervisory personnel time is spent on recording and analyzing field generated data. This amount of time may not apply to all field operations data management. Therefore, an automated process that incorporates the use of automatic identification and other information technologies could significantly alter and benefit the material delivery process saving much time. Technically, utilizing an automated system would make the transfer and compilation of this information more accurate and efficient.

If material delivery data can be automated from inception through finality, accuracy, reliability, and productivity of those involved can improve. One can expect less time handling, recording, and processing daily delivery tickets, electronic reconciliation of data and improved payment records. Another outcome is daily, weekly, or monthly summaries of the materials can be generated automatically. Thus, the main purpose of this project is to evaluate how to automate this process. Another purpose is to make sure this process includes the transfer of this data into SiteManager.

Work Activities

The primary objective of this project is to propose a process that will electronically transfer materials information between material suppliers, trucking companies, project personnel and contractor. This process includes material suppliers' ability to produce documents that can be recorded and tracked using automatic identification technology.

Since this is a "paper trail" issue, the study collects information on similar applications and recommends some options to consider for automating material delivery on the contracts of highway construction projects. The activities include the following.

- Collect information on methods and technologies (hardware and software) that can be used for this application.
- Survey other state agencies on how they perform this process.
- Perform a literature survey on what other industries do with a similar process.
- Contact material suppliers and trucking companies (aggregate, concrete, asphalt) and collect what options are available and feasible.
- Determine what tools and methods are compatible with SiteManager.
- Develop a report that summarizes the findings and describes the implementation issues and costs.

These activities serve to identify ways to:

- Improve the function of material delivery tickets
- Automate materials delivery data from inception through finality of a project
- Electronically summarize materials data on a regular basis
- Interface with SiteManager

Literature Review

A literature review was conducted to understand current technologies that could be used to automate materials delivery records. Among available technologies, this study mainly focused on using a bar code application and related hardware and software. The literature review also included a review of the typical material delivery procedure in the construction industry and similar delivery processes in other industries.

Automatic Identification and Data Capture (AIDC)

Automatic Identification and Data Capture (AIDC) is a collection of technologies that obtain data by machine readable symbols or through digital data transfer. Data capture can be accomplished in diverse ways. First generation technology includes bar codes, OCR (Optical Character Recognition), and magnetic stripes which have been used in various industries. More recently, some more advanced technologies, such as RFID (Radio Frequency Identification), smart card, voice recognition, and biometrics, are employed to collect data. Coupled with wireless communication technology, the AIDC facilitates efficient automatic data collection and transmission.

The data capturing method can be determined according to the purpose of the application and available infrastructure. Since this project is focused on materials delivery data on site and transmitting the data to a server for storage, bar codes are one possible reasonable cost option. As a machine-readable image, the bar code is one of the most widely used AIDC methods to accomplish speedy, accurate data entry. A study shows scanning bar code data is six to ten times faster than manual keying. Besides saving data entry time, accuracy is also improved with bar code over manual data entry. The error rate of manual data entry is said approximately 1 in 300 whereas an error rate with bar code is lower than 1 in 3 million.

Today, bar code applications are plentiful. One example is a bar code label on merchandise. The application of the bar codes can be easily observed at a grocery store.

Thus, the following section discusses state-of-the-art bar code technology and hardware and software components that are needed for bar code applications.

Symbology

Symbology is the term used to represent the pattern of bars found in a bar code. The bar code was originally developed in a linear format (or one dimensional bar code) with vertical bars printed on a label. Whereas the original symbologies represented numeric data only, newer symbologies can encode alphanumeric characters using ASCII (American Standard Code for Information Interchange) format.

Two dimensional (2D) bar codes have become common in many industries. A good example is a freight company like USPS (United States Postal Service). Two dimensional bar codes can represent multiple data fields. Figure 1 shows some examples of 1D and 2D bar codes.

(a) 1D Bar Code (b) 2D Bar Codes

Figure 1. Example of Bar Codes

Hardware

The bar code application requires a scanner and printer. Some options are listed below.

- Bar Code Reader (Laser and Imager)
  - USB Linear Bar Code Scanner
  - 2D Bar Code Scanner

    - Wireless Scanner with Bluetooth
    - PDA with bar code imager

- Bar Code Printer
    - Direct Thermal Printer
    - Thermal Transfer Printer
    - Common ink-jet or laser-jet printer

Bar code readers can typically be classified as a laser scanner or optical imager. There are many options available from numerous manufactures. Cost varies anywhere from less than one hundred dollars to several thousand dollars depending on its capability. The laser scanners are popular, but the optical imager becomes more attractive especially in reading 2D bar codes. In this project, a Bluetooth enabled pen-based scanner (Figure 2) was tested because it is believed to be an easy-to-carry, economical solution.

Figure 2. Pen-based Bar Code Scanner

In addition, all-in-one device such as a PDA (Personal Digital Assistant) with a built-in bar code scanner is popular in the market (Figure 3). This device can also transmit the collected data to a remote server using its wireless data communication capability through a commercial cellular network.

Figure 3. PDA Bar Code Scanner

Most printers can print bar codes by using bar code printing software. Direct thermal printer or thermal transfer printer can be used for printing individual bar codes, but one can also use the ink-jet or laser-jet printer to print out a document with several bar code images included.

Software

Most bar code scanners come with software that is compatible to various operating systems so that one can use the software to scan and store information in a computer. One can also find many printing software options to print individual bar codes or to embed bar codes on a form. If one wants to generate a specific form with bar codes, typically custom software is needed. Commercial couriers such as FedEx or UPS use their websites to generate an embedded bar code. The following is a summary of software options.

- Free software provided by hardware manufacturers
- Commercial bar code printing software
- Web application that generates printable bar coded documents

Materials Delivery Procedure

In a typical construction project, a general contractor is responsible for the installation, quality, budget, schedule, and safety of the project. It is not uncommon for a general contractor to subcontract some portion of the work scope stipulated in the contract to companies that specialize in certain areas of construction.

During the construction period, the material supplier periodically submits a pay application to the general contractor for material installed. This is where accurate record keeping becomes valuable. It is important that a record be kept of the amount of materials delivered and installed. This is usually done by summing delivery tickets. In a large civil project, such as airport runways, high-rises, and highway construction and reconstruction, this can be very time consuming.

Looking at other industries, many shipping companies such as DHL, FedEx, UPS, and the United States Postal Service (USPS) use some form of automated on-line package tracking system. Their systems are based on internet monitoring. The following describes a typical shipping procedure using internet monitoring just for a reference. However, this procedure is not used on most construction projects.

1. Customer places order.
2. Business receives Notice of Sale(s), along with details of order.
3. Business assigns order number for internal sales tracking.
4. Business notifies customer of received order via e-mail that includes order number, overall cost, and details of transaction.
5. Business transfers order to shipping department.
6. Shipping Department enters order into organizational software.
7. Shipping Department procures item(s) and packages item(s) for shipping.
8. Shipping Department places order with shipping supplier via internet.

Business specifies package size, weight, time frame, location shipping to, customer contact information, and shipping method. Package tracking includes tracking number, traceable via internet or phone.

9. Business is charged by shipping courier on corporate account or credit card.
10. Business notifies customer via e-mail of item(s) shipped.
11. Shipping Department places shipping supplier's printed labels on item that typically includes tracking number on package for internal use.
12. Shipping courier sends employee with large vehicle for order pickup.
13. Employee scans barcode on the package, logging into shipper's system.
14. Package is transported back to regional hub of company; and package's barcode is scanned again as received at regional hub.
15. Package is transported to regional hub of package's destination; and package's barcode is scanned again as received at new regional hub. All the above scanned information is available through a website for a tracking purpose.
16. Shipping courier's driver delivers package to vendor and scans package into system as delivered; and customer and business are notified of completed delivery.

Next is a typical procedure for delivering bulk materials to a construction project, concrete is used.

- The contractor places an order to a concrete company.
- Concrete company loads a mixer and generates a ticket.
- Concrete company's mixer arrives and offloads concrete on site.
- The driver hands a material delivery ticket to the contractor's or owner representative for signature.
- A copy of the ticket is kept on site and the original is sent back with the mixer to the concrete company's accounts department and is used to develop an invoice.

Figure 4 shows a typical procedure of materials delivery. Shaded areas indicate procedures that can be automated.

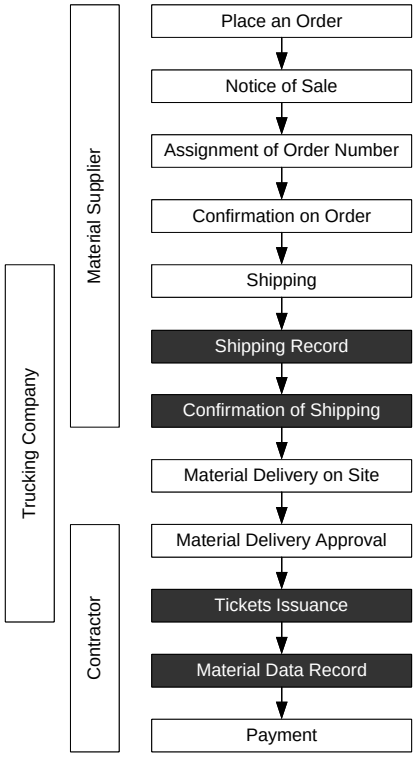


Figure 4. Typical Materials Delivery Procedure

Figure 5 shows a schematic diagram of a conceptual plan for the automated materials delivery procedure. The schematic diagram shows how the data is generated, processed and transmitted from the material supplier, through trucking company, and to the contractor on site. It also explains how the data is recorded by the all project participants. The procedure includes:

1. A material supplier generates a ticket with bar codes.
2. Materials are delivered to the job site. Delivery ticket bar codes are used for data entry.
3. INDOT inspector collects delivery tickets and scans. Material data is transferred to material management software (e.g. SiteManager).
4. The scanned data is transmitted to the contractor as a receipt.

5. The scanned data is transmitted to trucking company and material supplier and reconciled with their records.

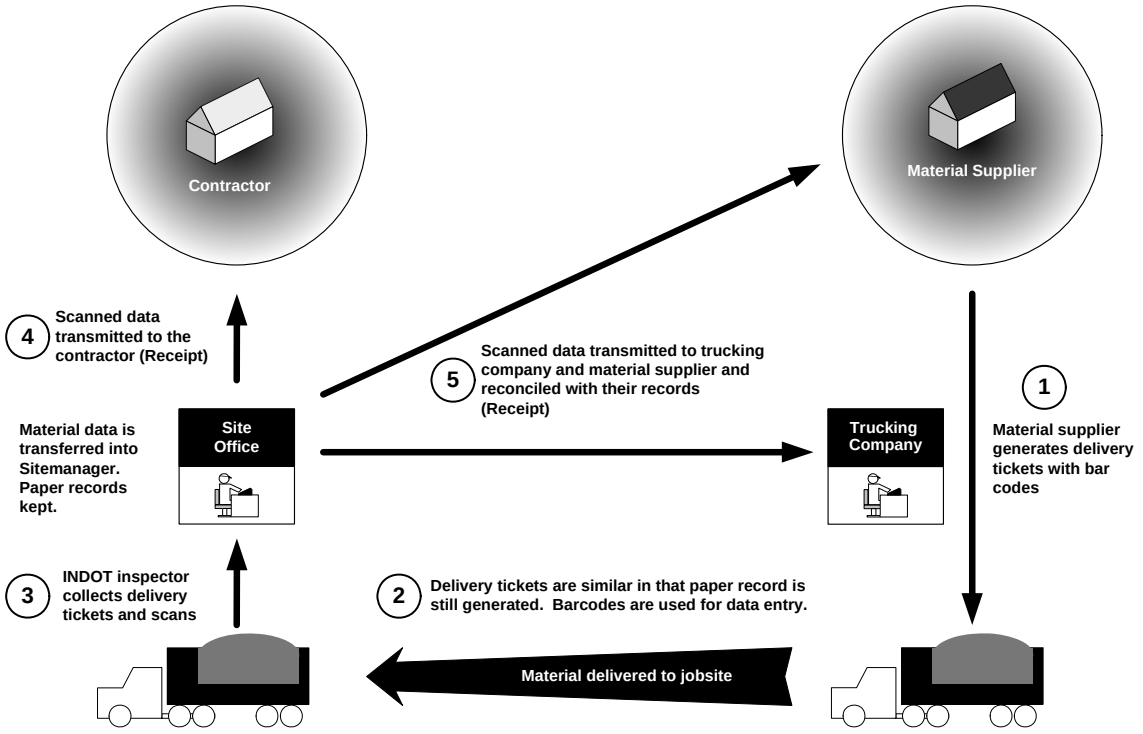


Figure 5. Schematic Diagram of Automated Materials Delivery Procedure

Case Studies

Case studies were conducted with the assistance of bar code scanner manufacturers. The following case studies describe the system requirements to automate tracking material delivery records and lessons learned from previous applications by answering the following questions.

1. What kinds of systems are currently used in other industries for automated material delivery tracking?
2. What type of software and hardware are required?
3. Any cost benefits by implementing their applications?
4. Any technical challenges or problems in their applications?

Case 1: 20/20 Delivery® by Tele Communication Systems and Symbol (Source: Symbol)

20/20 Delivery is a wireless logistics solution from TCS (Tele Communication Systems) that provides complete visibility into the supply chain from delivery, service, and vehicle tracking, to driver management and cost control. 20/20 Delivery has several capabilities including tracking billing cycles, real-time electronic proof of delivery using handheld device technology, and monitoring driver and vehicle productivity. The following shows some notable features, advantages, hardware requirements, network options for the system, configuration options, and back-end supports.

Notable features

- Driver and customer signature capture
- Date and time stamping
- Delivery monitoring
- Bar code scanning
- Back-end reporting
- Receipt printing

Advantages

- Cost effective delivery tracking
- Deployment time management
- Real time delivery management via a road map
- Immediate report to accounting systems for billing

Hardware requirements

- Network Server
- GPRS (Global Pocket Radio Service) Enabled Handheld Device
- Bar Code Scanner
- Receipt Printer

Network Options

- GSM (Global System for Mobile Communication)/ GPRS
- Mobitex
- 1xRTT
- iDEN (Motorola)

GSM is a cellular network standard for mobile phones and GPRS is a mobile data service available to users of GSM and IS-136 mobile phones. Mobitex is an OSI (Open System Interconnection) based open standard, national public access wireless packet-switched data network developed by Ericsson. 1xRTT (Single-Carrier Radio Transmission Technology a.k.a. CDMA2000) is a 2.5G wireless technology based on the CDMA platform. 1xRTT has the capability of providing ISDN-like speed up to 144 kbps. iDEN (Integrated Digital Enhanced Network) is a mobile telecommunications technology, which provides its users with the benefits of a trunked radio and a cellular telephone.

Configuration Options

- Integrated Radios (e.g. Symbol MC9060-G Series)
- Tethered Radios (in-vehicle equipment)

The Symbol MC9060-G (MC9000-G Series) delivers scanning and imaging technologies. One can select a laser barcode scan engine or an imager depending on the application requirements. The MC9060-G (MC9000-G Series) features multimode wireless communication that offers real-time access to data.

Back-End Support

- Aether Fusion (Aether's Middleware Architecture)
- Application Server Support (BEA WebLogic 6.1 or above, JBOSS 3.0.x)
- Cross Platform Support (Sun Solaris, MS Windows 2000, XP Professional)
- Database Portability (MS SQL Server 2000, MySQL, Oracle)

Aether Systems, Inc. is a wireless and mobile data products and services provider that provides real-time communications and transactions across a full range of devices and networks. BEA Weblogic is a J2EE Platform product family that supports Oracle, DB2, Microsoft SQL Server, MySQL Enterprise and other JDBC-compliant databases. JBoss is an open source Java EE-based application server.

Typical delivery process with 20/20 Delivery® can be broken into four major steps in accordance with geographical location of a delivery truck: On Shipping Site, In Vehicle, On Delivery, and Back to Office. Figure 6 shows a simplified delivery process. Two scanned images of the PDA used for delivery represent what information can be seen on the screen.

Delivery Process

On Shipping Site
• Pick up a handheld device. • Receive delivery information.

⇓

In Vehicle
• Log in with a driver ID. • Scan an invoice. • System automatically initiates time clock. • Confirm customer and delivery information.

⇓

On Delivery
• Take the device from the vehicle. • Scan bar codes. • Collect electronic signatures. • Confirm delivery with the main office in real time.

⇓

Back to Office
• Log out. • Return the handheld device.

Figure 6. 20/20 Delivery® Delivery Process

Delivery Reports

After completion of a delivery, a delivery report can be generated. Detailed delivery information can be reported to a drivers and vehicles manager. The information shown in the reports can also be graphically presented on a road map. Figure 7 shows a sample report which includes the following information.

- Time and mileage information
- Fuel usage
- Percent completion of delivery
- Bar code scanning information
- Driver information

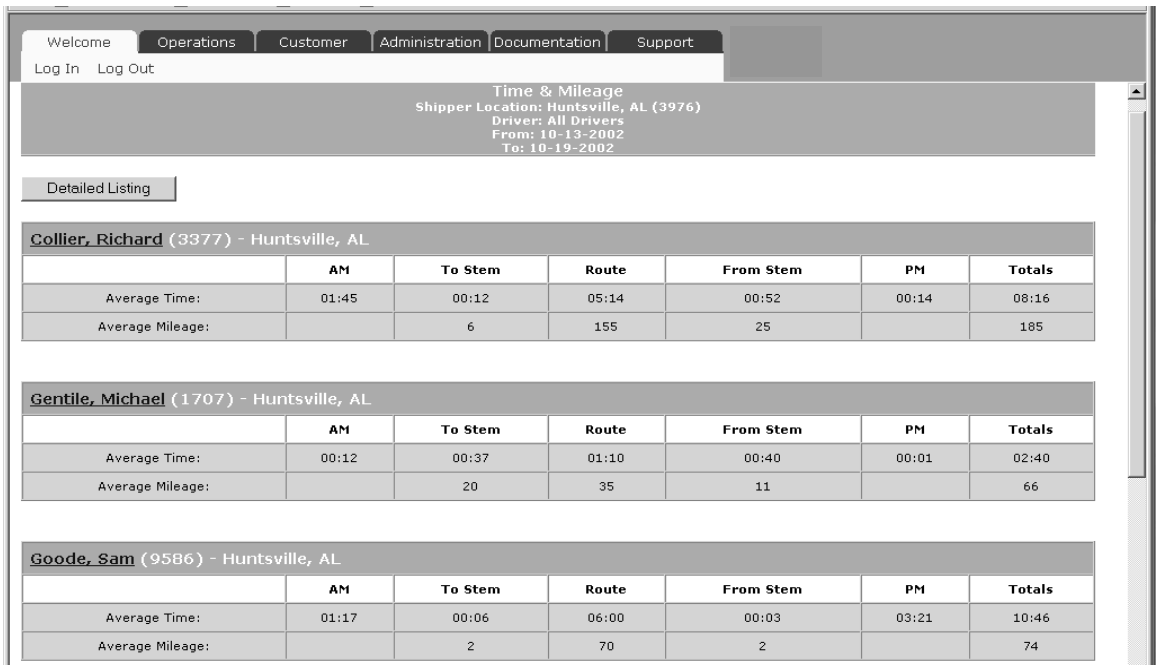


Figure 7. Sample Report

Customer Service Reports

Customer Service Reports are designed to provide a quick access to order information. Customers can go to a website and search for order information by sales order ID, customer ID, or package ID. Email confirmation will also be sent to the customers. Figure 8 shows a website that shows a sample delivery confirmation.

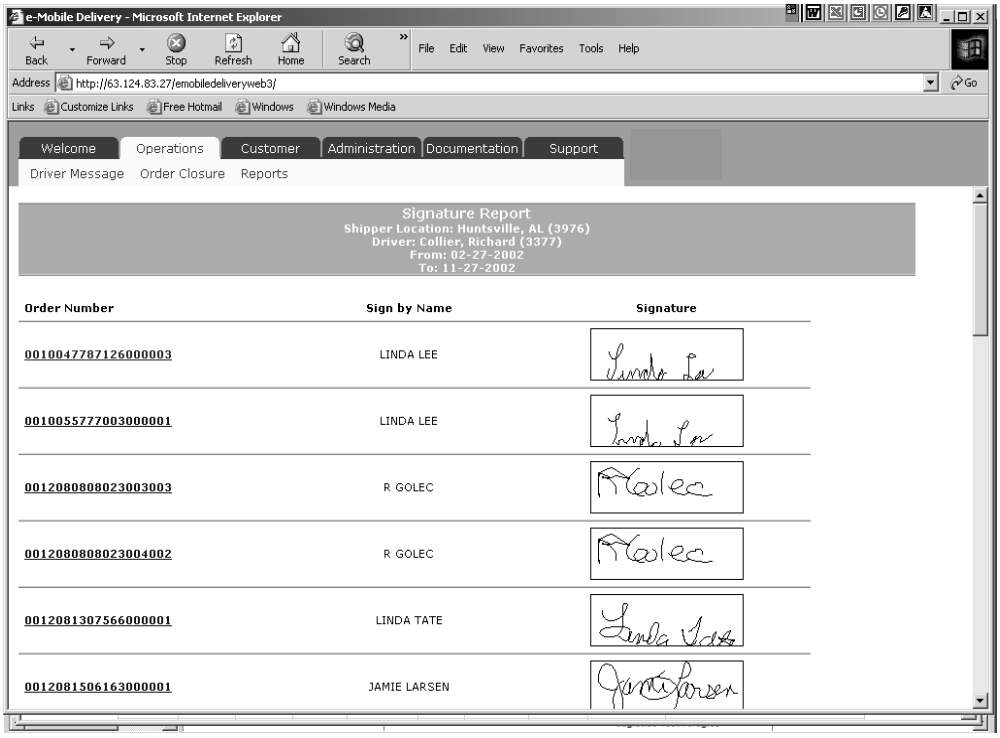


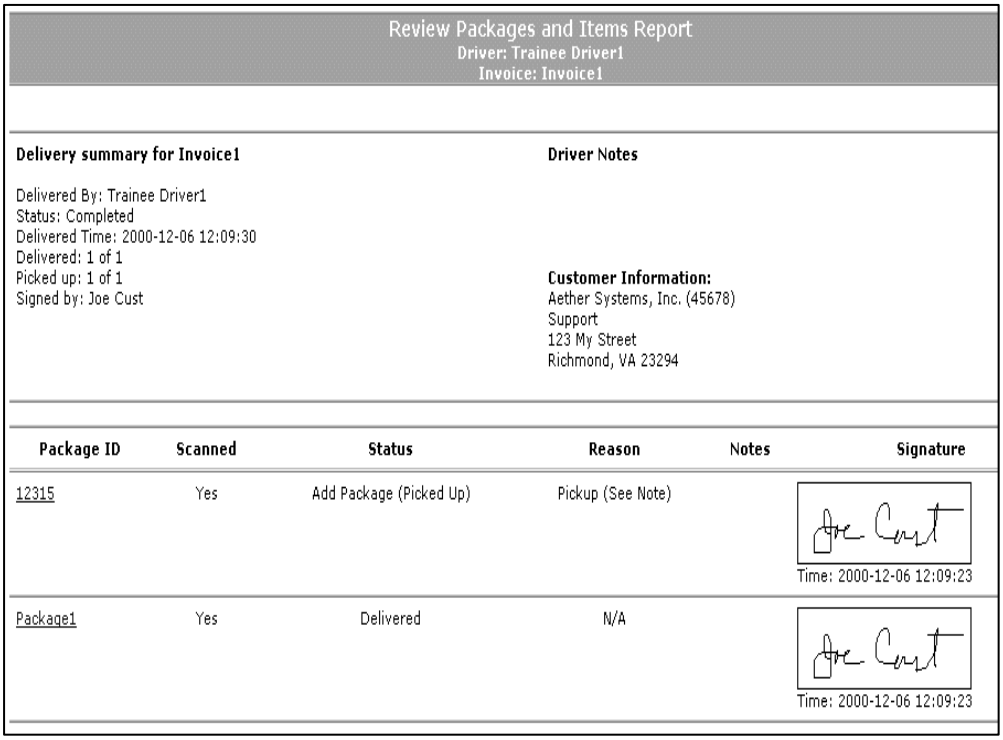
Figure 8. Sample Customer Information

Manifest Report

Figure 9 shows a sample manifest report which includes the following information.

- Electronic signatures with date and time
- Package ID
- Scan confirmation
- Order status

- Reason for activity
- Activity summary (driver name, status, delivery/pick-up, and customer name)
- Customer information



Review Packages and Items Report
Driver: Trainee Driver1
Invoice: Invoice1

Delivery summary for Invoice1

Delivered By: Trainee Driver1
Status: Completed
Delivered Time: 2000-12-06 12:09:30
Delivered: 1 of 1
Picked up: 1 of 1
Signed by: Joe Cust

Driver Notes

Customer Information:
Aether Systems, Inc. (45678)
Support
123 My Street
Richmond, VA 23294

Package ID	Scanned	Status	Reason	Notes	Signature
12315	Yes	Add Package (Picked Up)	Pickup (See Note)		Time: 2000-12-06 12:09:23
Package1	Yes	Delivered	N/A		Time: 2000-12-06 12:09:23

Figure 9. Sample Manifest Report

Case 2: Automatic Identification Technology using 2D Bar Code (Source: Intermec)

The project team has attended a webinar (the author's annotation: an online live seminar through the Internet) from Intermec which is one of the nationwide companies who provide automated information and data capture (AIDC) and mobile computing systems. The webinar was focused on using 2D bar codes for warehouse and distribution systems. The following section describes what was covered in the webinar.

2D bar code applications have been growing in many industries in the states. The applications are but not limited to US DOD logistics, pharma & healthcare, retail and consumer goods manufacturing, industrial manufacturing, and transportation. The reason for these growing 2D applications include current industry trend towards marking smaller items, need for more information to travel, traceability issues, etc. With advances in area imager technology, 2D symbols can be a promising technology that may benefit many areas in the industry. The following case studies introduce some problems experienced during delivery and possible application solutions utilizing 2D bar codes.

2D Barcode Implementation in the US Air Force

One of the shipping challenges identified during the course of delivery is what they call "no hits." Delivery cargo arrives before the data comes into the system. Therefore this process outpacing the data may lead to serious delays in delivery due to cargo's awaiting documentation. Another concern will be manual handling of jammed shipment data into multiple systems in multiple times which may result in input errors. In many bar code applications, linear bar code (or 1D bar code) work well for data-light applications, but did not have sufficient data capacity to automatically enter shipment data. This is actually where one demands 2D bar code applications for speedy process. The solution for this may include a 2D bar code on shipping label to automatically scan and transfer data to the successive delivery spots.

Lessons Learned from Bar Code Shipping Label

With a bar code shipping label, data input time and data accuracy improves. This has been proven in other industries and can be used in similar fashion in the construction industry. However, even with these obvious advantages, implementation into INDOT's operations has some inherent problems expressed by stakeholders in the process. This may be an issue in the material suppliers industry because they have different systems used for handling materials delivery data. Therefore, this may be the issue that INDOT needs to consider when developing a bar code application for tracking materials delivery. This is also addressed in more detail in this report where it describes inputs from aggregate and pavement contractors.

Benefits of 2D Package Label

There are two major benefits associated with using 2D bar code in shipping. One is an improved shipping process. It provides accurate data during the packaging process. Also, one can experience seamless transfer of order/package data during the shipping process. In a similar manner, the receiving process benefits through the use of a 2D label. The 2D label provides improved tracking and allows for more encoded data than 1D labels can provide.

Enhanced Security

Another benefit from using a bar code label could be avoidance of touching the data. This may be an issue in the scale house when truckers load their materials to be delivered to a construction site. Using bar code may provide a secured process to have the delivery data intact during the course of materials delivery.

Through the literature review and case studies, the project team identified state-of-the-art bar code technologies, explored some applications used in other industries, and discussed lessons learned. The following sections describe inputs from other state transportation

agencies and stakeholders in the construction industry for INDOT to consider when considering automating material delivery.

Inputs from State Transportation Agencies

Survey State Transportation Agencies (April 2007)

Overview

An online survey was performed with the help of Dr. Barry Partridge and Brandon Stevens at INDOT Research Division in April 2007. The primary purpose of the survey was to investigate if any state transportation agencies are currently using automated methods in tracking materials for transportation projects. Eleven questions were asked in the survey with the actual survey form in Appendix A. The questions are:

1. Does your Agency have an automated material delivery tracking system for transportation construction projects? (If they answered no to this question, they were guided to proceed to Question 9).
2. Please describe the system components of your material delivery tracking system (Field Components and Office Components)
3. If your system utilizes bar codes or other types of automatic identification technologies, please describe the system components and technology being used.
4. What are the beneficial factors from using your automated material delivery tracking system?
5. With regard to the method being used in your State, please describe the challenges or limitations which could be the most problematic.
6. What are the disadvantages of your automated material delivery system?
7. Does your Agency have a training program for this system?
8. In what format, does your Agency implement the training program?
9. Is there a strong need to develop an automated material delivery tracking system on construction projects?
10. Would you like to receive a copy of the result of this survey?
11. May we contact you to collect more information about your material delivery tracking system?

A total of seventeen (17) state agencies responded to the questionnaire. They were Kansas, Wyoming, Rhode Island, Oregon, Nevada, Georgia, Oklahoma, Montana, Louisiana, Maryland, Ohio, Texas, Arkansas, Maine, Iowa, New Jersey, and British Columbia

Based on these 17 responses, no state transportation agency at the moment, have any form of automatic materials tracking system in place. Some state agencies are in the process of implementing AASHTO SiteManager to track materials data, with INDOT one of them.

Survey Results and Review

Question1-Does your Agency have an automated material delivery tracking system for transportation construction projects?

Only two States, Louisiana and New Jersey, answered yes to this question. However, they are still in the process of implementing AASHTO Trns*port SiteManager only to handle their materials data after manually collecting them on site. Figure 10 shows the survey result for Question 1.

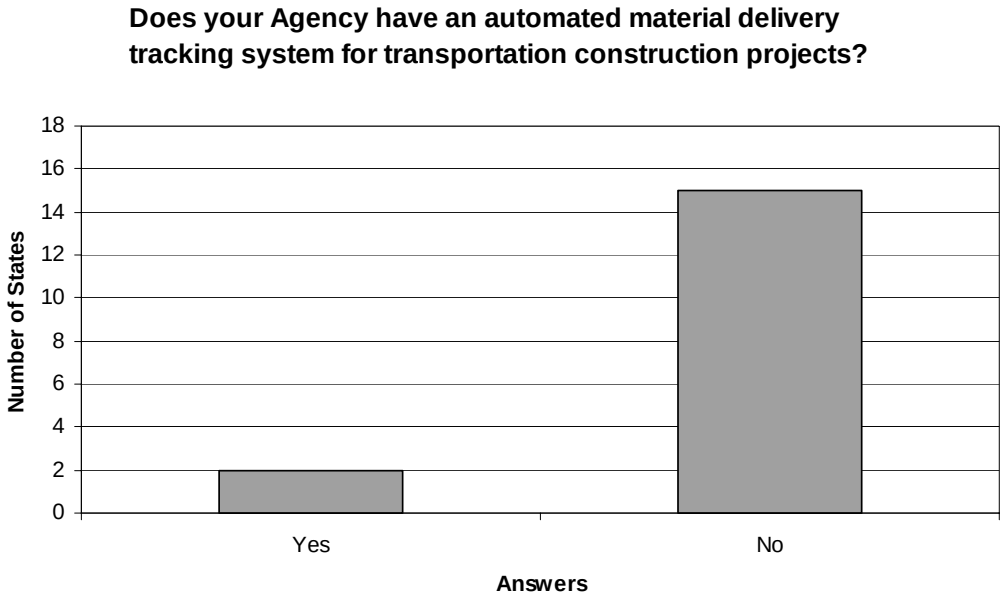


Figure 10. Result of Survey Question 1

Question 2- Please describe the system components of your material delivery tracking system (Field Components and Office Components).

Below are the actual responses from several state agencies.

Nevada:

"At this time the Nevada Department of Transportation uses paper transmittals for submitting construction materials delivery. It is not automated and not necessary a tracking system."

Montana:

"We are in the process of implementing the AASHTO SiteManager and Materials systems which should provide this function. Also, the LIMS (Laboratory Information Management Systems) will be added to the SiteManager suite in the future."

Louisiana:

*"AASHTO Trns*port SiteManager"*

New Jersey:

*"We are in the process of implementing AASHTO TRNS*PORT SiteManager for both Construction and Materials. Field inspectors will use laptops to do their daily work reports. We are scheduled to be up and running Spring 2008."*

"Field offices will be equipped with desk top PCs to allow the inspectors the choice of submitting via their laptop or -dumping- their reports via the desktop. All field offices will be required to have high speed Internet connections."

Question 3- If your system utilizes bar codes or other types of automatic identification technologies, please describe the system components and technology being used.

Only one state agency, Georgia, is planning on using a form of automatic identification technology, RFID (Radio Frequency Identification) technology to track materials data for their construction projects.

Question 4- What are the beneficial factors from using your automated material delivery tracking system?

This is a multiple choice question asking about the benefits that can be taken from using the automated tracking system. Louisiana and New Jersey checked all the following benefits listed in the question.

- Ease in data logging/record keeping
- Communication between project entities
- Reconciliation of material records
- Data accuracy
- Compatibility to project management system

Question 5 - With regard to the method being used in your State, please describe the challenges or limitations which could be the most problematic.

New Jersey mentioned a network problem as the foremost concern in using the automated materials tracking system.

Question 6 - What are the disadvantages of your automated material delivery system?

There were no responses to this question.

Question 7- Does your Agency have a training program for this system?

Both Louisiana and New Jersey have training programs.

Question 8 - In what format, does your Agency implement the training program?

Louisiana runs a combination of online, on-the-job, classroom-based trainings for their employees. New Jersey has classroom-based training.

Question 9 – Is there a strong need to develop an automated material delivery tracking system on construction projects?

Seven (7) state agencies (41%) answered that they need an automated material delivery tracking system for their transportation construction projects. Figure 11 shows the survey result for Question 9.

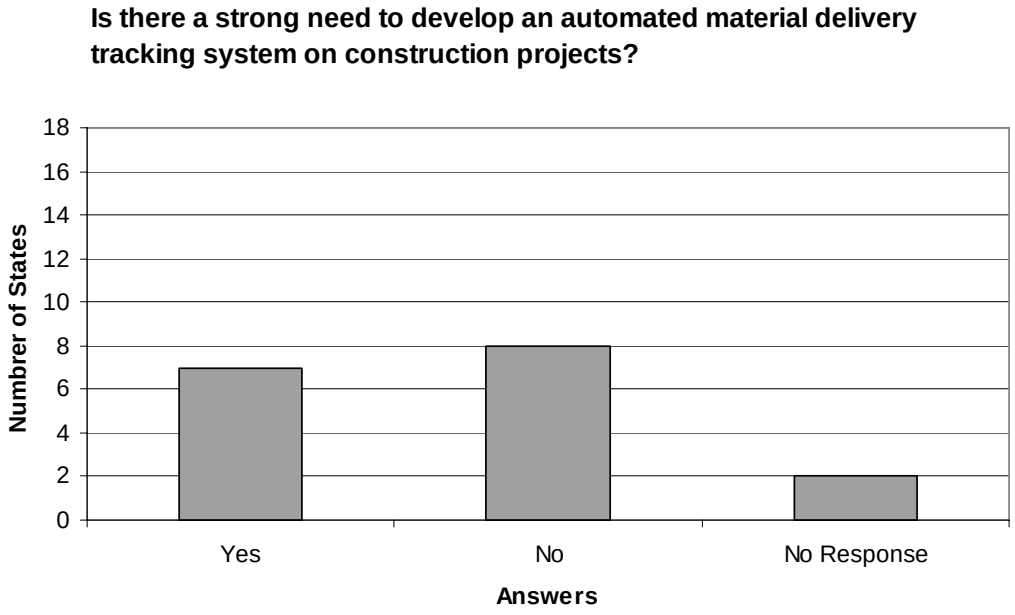


Figure 11. Result of Survey Question 9

Questions 10 and 11 are general survey questions that ask if they want to receive the survey results and if they are willing to be contacted by this project team to discuss some other pertinent issues on this project.

Inputs from Pavement and Aggregate Producers

Survey Aggregate Producers (June 2007)

Overview

Another survey during the course of this study was performed in June 2007. The purpose of the survey was to investigate if any aggregate producers are currently using software in tracking materials information such as ticketing, accounting, or other administrative activities and what software is used. Seven questions were asked in the survey with the actual survey form in Appendix B. The questions are:

1. Does your company use any software for materials tracking?
2. Is your software an in-house application or a commercial one?
3. If you currently use commercial software, please provide us with software name.
4. Please describe the main features of your software.
5. Do you use the aforesaid software to generate a ticket?
6. What information is included in your delivery ticket?
7. May we contact you to collect more information about your software?

Survey Results and Review

A total nine (9) aggregate producers responded to the questionnaire. The following is the list of producers who responded.

- Rogers Group Inc.
- Global Software Inc.
- Sellersburg Stone Company (2 responses)

- Engineering Aggregates Corp.
- Stone-Street Quarries Inc.
- Vulcan Materials Company – Midwest Division
- Vulcan Materials Company – Birmingham, AL
- New Point Stone Co.

Based on these nine responses, it is found that the aggregate producers currently use various kinds of software packages. Most of them are using commercial software packages. The following is the list of commercial software packages for materials tracking used by those responders.

- Global Software
- JWS, a division of Command Alkon
- Integrated Management Software
- BMG Seltec Premium Enterprise

Among software in the list, JWS used by three responders is known as one of the most popular ones in the State of Indiana. Although it is not included in the survey responses, Rexcon in Milwaukee, WI is another popular software package used by many material producers. Both can include bar codes in the ticket. Although majority of the responders expressed positive envision of using bar codes in the ticket, some do not see a big advantage to the bar coding of tickets and show concerns about additional expenses. The following is the detailed review of each response.

Rogers Group Inc.

Rogers Group uses a truckscale to have orders, jobs, product codes, and truck numbers loaded into the system and print material information on the ticket.

Global Software Inc.

Global Software is not a material producer but a software developer. Global Software can interface with a scale indicator for the capture of scale weight. It has a database of:

- Haulers
- Customers
- Jobs
- Products
- Costs
- Tickets
- Invoices
- Reporting

Global Software shows an intention to offer no cost to reproduce the information already printed on the ticket in a barcode assuming all tickets would contain bar codes. According to their response, it is an easy task to include the bar code functionality as part of the custom ticket that they offer all of their customers. In order to optionally control customers/jobs for those who do not use bar codes, the development cost may be around $1,000 at minimum.

Sellersburg Stone Company

Sellersburg Stone Company uses JWS, a division of Command Alkon, which offers an integrated solution for materials tracking. Main features of JWS include auto ID, truck activity monitoring, daily/continuous material totals, material sorting by project and product codes, and data transferring between software.

Engineering Aggregates Corp.

Engineering Aggregates Corp. currently uses Integrated Management Software. The main features of the software are generating tickets and daily material reports at the scale house. Daily materials and customer reports, invoices and statements can be created at the office.

They expressed an intention to upgrade their system at the scalehouse in order to put bar codes on their tickets. However, it requires them to replace their current printers and software.

Stone-Street Quarries Inc.

Stone-Street Quarries uses Integrated Management Systems for materials tracking. The system has the following five fields to be completed to process a delivery ticket.

- Truck number
- Customer name
- Job number
- Type of material
- Truck delivery freight

From the information above, ticket is printed and billing, sales, inventory, and other management reports can be generated.

Vulcan Materials Company, Midwest Division

VMC uses Premium Enterprise by BMG Seltec which is a fully-featured material tracking program. BMG Seltec currently offers solutions for aggregate, asphalt, and concrete producers separately. For the aggregate sites, the main features include auto ID, ticketing, check-in/out kiosk, checking weights, and wireless loader information. But, it does not print bar codes on tickets.

Vulcan Materials Company in Birmingham, AL

VMC in Birmingham currently uses their in-house program for materials tracking.

New Point Stone Co.

New Point Stone Co. also uses JWS for their ticketing, invoicing, accounting, and reporting.

Typical Information on Ticket (actual names may vary)

Based on the survey and interviews with material producers, the following list includes typical information to be shown in a delivery ticket. Since there are many material producers that supply to INDOT, some of the names listed below may not be the same as what they use in their tickets. The readers may take this information as data fields to be stored in the INDOT project management system database.

- Ticket Number
- Date and Time
- Customer Code
- Customer Name
- Job Code
- Purchase Order (PO) Number
- Contract Number (IDNOT Contract Code)
- Project Number (Internal Use)
- Hauler Name
- Truck Code
- Source Name
- Queue Number
- Product Code
- Product Name
- Location
- Gross Weight
- Tare Weight
- Net Weight
- Aggregate Size

- Type of Mix
- Accumulative Running Total to the current Job
- Additional Internal Information

Concrete Pavement (Based on PCCP Meeting on June 20, 2007)

The following describes comments received from a PCCP meeting and interview with a concrete batch plant producer during the project period.

Payment Units

Concrete items have different measurement units. For example, concrete pavement is measured in square yards, curbs and barriers use linear feet. Also, as far as payment in some cases, materials are not paid separately but included in the entire structure. Since some items are not paid by the amount of material delivered, bar codes would not be helpful in tracking pay quantities.

Delivery Ticket Software

There are two major software programs that are currently used by materials suppliers in the state of Indiana, RexCon and Command Alkon. Both are able to generate bar coded delivery tickets. There are two concerns in generating bar code tickets. One is most batch plants currently use dot-matrix printers because of its reliability and durability. To print bar codes on a ticket would necessitate an ink-jet or a laser printer. Therefore, the current dot-matrix printers need to be replaced. In order to accommodate bar codes, the delivery tickets need be redesigned to some requirements specified by INDOT.

Despite these issues, many material producers are willing to modify their tickets to accommodate bar codes because they see an improved process and cost savings.

Bar Code Tickets for Materials Other than Bulk Materials

Materials like fences or guardrails, which are lesser in quantity, still need to be included when developing an automated system for material delivery. Even though these quantities will be smaller, a bar coded delivery ticket will bring the same benefits that can be experienced in bulk materials.

Concrete Batch Plant Producer (Based on input from E&B Paving)

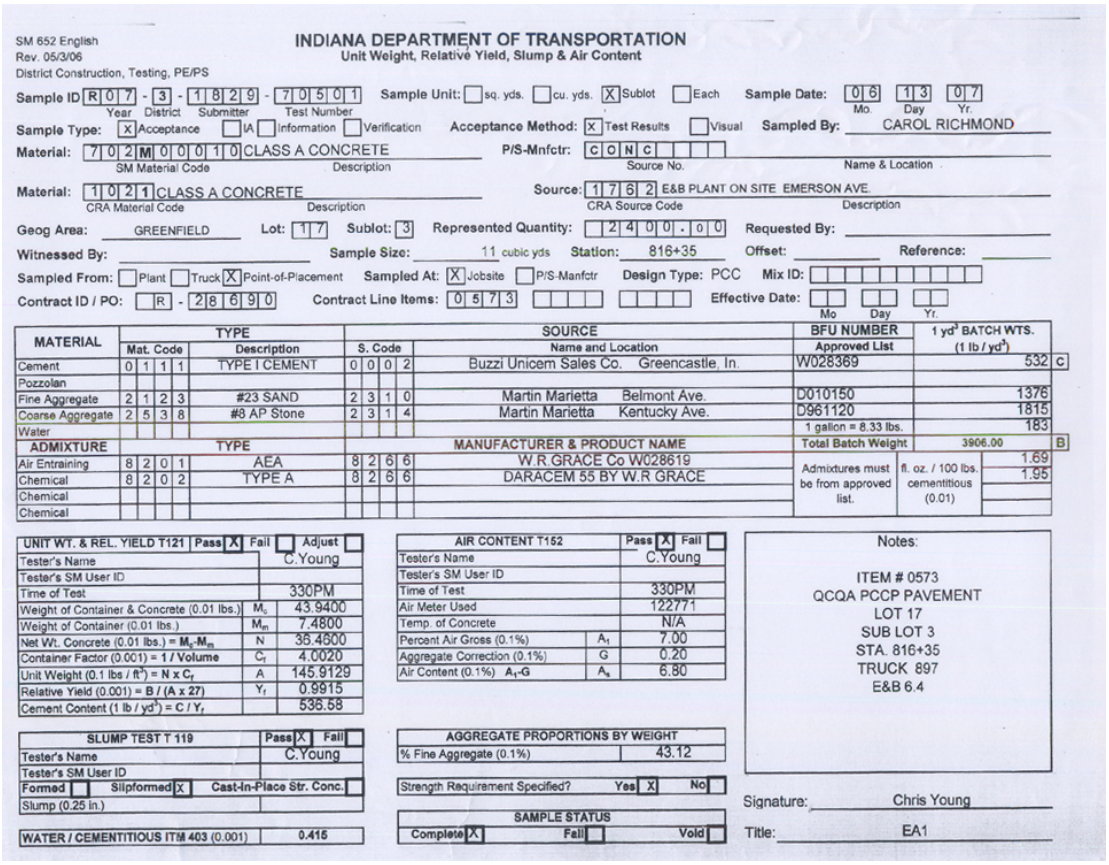
The project team visited E&B Paving Super 70 project office. Two forms are currently used by E&B Paving: one for material information (Figure 12) and the other is an INDOT record (Figure 13).

Ticket: 61 REPRINT 6/20/2007 10:32:40 AM
Customer Name: E & B Paving Job Name: 40060474
Delivery Address: FROM WEST SIDE OF EMERSON AVE. TO I-465
Job Description: R-28690
Instructions:
Formula: 530 530 Straight cement mi
Load Size: 11.00 yards
Daily Qty 671.00 Ord Qty 130,000 Del Qty 62,420 yards
Driver:
Truck: 0

Product Name	Actual		%M
SAND	15,160	lbs	2.6
STONE 3	9,920	lbs	0.5
STONE 2	9,980	lbs	0.5
CEMENT	5,870	lbs	0.0
WATER	234	gallons	
DAIRAVAIR 140	100	fluid ozs	
WRDA-20	114	fluid ozs	

Figure 12. Material Information from E&B Paving

These forms are used in concrete delivery. A bar coded ticket would contain some of these fields. For example, Martin Marietta Aggregates is a national company that has used bar codes on their delivery tickets. From the aggregate suppliers' perspective, it is costly to switch their ticket applications to a bar code labeled ticket. Some printers are not able to print bar codes so new printers would be needed. Also, new software is required for printing these types of tickets.



SM 652 English
Rev. 05/3/06
District Construction, Testing, PE/PS

INDIANA DEPARTMENT OF TRANSPORTATION
Unit Weight, Relative Yield, Slump & Air Content

Sample ID: R 0 7 - 3 - 1 8 2 9 - 7 0 5 0 1 (Year - District - Submitter - Test Number) Sample Unit: ☐ sq. yds. ☐ cu. yds. ☒ Sublot ☐ Each Sample Date: 0 6 (Mo.) 1 3 (Day) 0 7 (Yr.)
Sample Type: ☒ Acceptance ☐ IA ☐ Information ☐ Verification Acceptance Method: ☒ Test Results ☐ Visual Sampled By: CAROL RICHMOND
Material: 7 0 2 M 0 0 0 1 0 CLASS A CONCRETE (SM Material Code / Description) P/S-Mnfctr: C O N C (Source No.) (Name & Location)
Material: 1 0 2 1 CLASS A CONCRETE (CRA Material Code / Description) Source: 1 7 6 2 E&B PLANT ON SITE EMERSON AVE. (CRA Source Code / Description)
Geog Area: GREENFIELD Lot: 1 7 Sublot: 3 Represented Quantity: 2 4 0 0 . 0 0 Requested By:
Witnessed By: Sample Size: 11 cubic yds Station: 816+35 Offset: Reference:
Sampled From: ☐ Plant ☐ Truck ☒ Point-of-Placement Sampled At: ☒ Jobsite ☐ P/S-Manfctr Design Type: PCC Mix ID:
Contract ID / PO: R - 2 8 6 9 0 Contract Line Items: 0 5 7 3 Effective Date: (Mo / Day / Yr.)

MATERIAL	TYPE Mat. Code	TYPE Description	SOURCE S. Code	SOURCE Name and Location	BFU NUMBER Approved List	1 yd³ BATCH WTS. (1 lb / yd³)
Cement	0 1 1 1	TYPE I CEMENT	0 0 0 2	Buzzi Unicem Sales Co. Greencastle, In.	W028369	532 C
Pozzolan						
Fine Aggregate	2 1 2 3	#23 SAND	2 3 1 0	Martin Marietta Belmont Ave.	D010150	1376
Coarse Aggregate	2 5 3 8	#8 AP Stone	2 3 1 4	Martin Marietta Kentucky Ave.	D961120	1815
Water					1 gallon = 8.33 lbs.	183
ADMIXTURE	**TYPE**		**MANUFACTURER & PRODUCT NAME**		**Total Batch Weight**	3906.00 B
Air Entraining	8 2 0 1	AEA	8 2 6 6	W.R.GRACE Co W028619	Admixtures must be from approved list. / fl. oz. / 100 lbs. cementitious (0.01)	1.69
Chemical	8 2 0 2	TYPE A	8 2 6 6	DARACEM 55 BY W.R GRACE		1.95
Chemical						
Chemical						

UNIT WT. & REL. YIELD T121 Pass ☒ Fail ☐ Adjust ☐		
Tester's Name		C.Young
Tester's SM User ID		
Time of Test		330PM
Weight of Container & Concrete (0.01 lbs.)	M_c	43.9400
Weight of Container (0.01 lbs.)	M_m	7.4800
Net Wt. Concrete (0.01 lbs.) = M_c-M_m	N	36.4600
Container Factor (0.001) = 1 / Volume	C_f	4.0020
Unit Weight (0.1 lbs / ft³) = N x C_f	A	145.9129
Relative Yield (0.001) = B / (A x 27)	Y_f	0.9915
Cement Content (1 lb / yd³) = C / Y_f		536.58

AIR CONTENT T152 Pass ☒ Fail ☐		
Tester's Name		C.Young
Tester's SM User ID		
Time of Test		330PM
Air Meter Used		122771
Temp. of Concrete		N/A
Percent Air Gross (0.1%)	A_1	7.00
Aggregate Correction (0.1%)	G	0.20
Air Content (0.1%) A_1-G	A_s	6.80

SLUMP TEST T 119 Pass ☒ Fail ☐	
Tester's Name	C.Young
Tester's SM User ID	
Formed ☐ Slipformed ☒ Cast-In-Place Str. Conc. ☐	
Slump (0.25 in.)	
WATER / CEMENTITIOUS ITM 403 (0.001)	0.415

AGGREGATE PROPORTIONS BY WEIGHT	
% Fine Aggregate (0.1%)	43.12

Strength Requirement Specified? Yes ☒ No ☐

SAMPLE STATUS		
Complete ☒	Fail ☐	Void ☐

Notes:
ITEM # 0573
QCQA PCCP PAVEMENT
LOT 17
SUB LOT 3
STA. 816+35
TRUCK 897
E&B 6.4

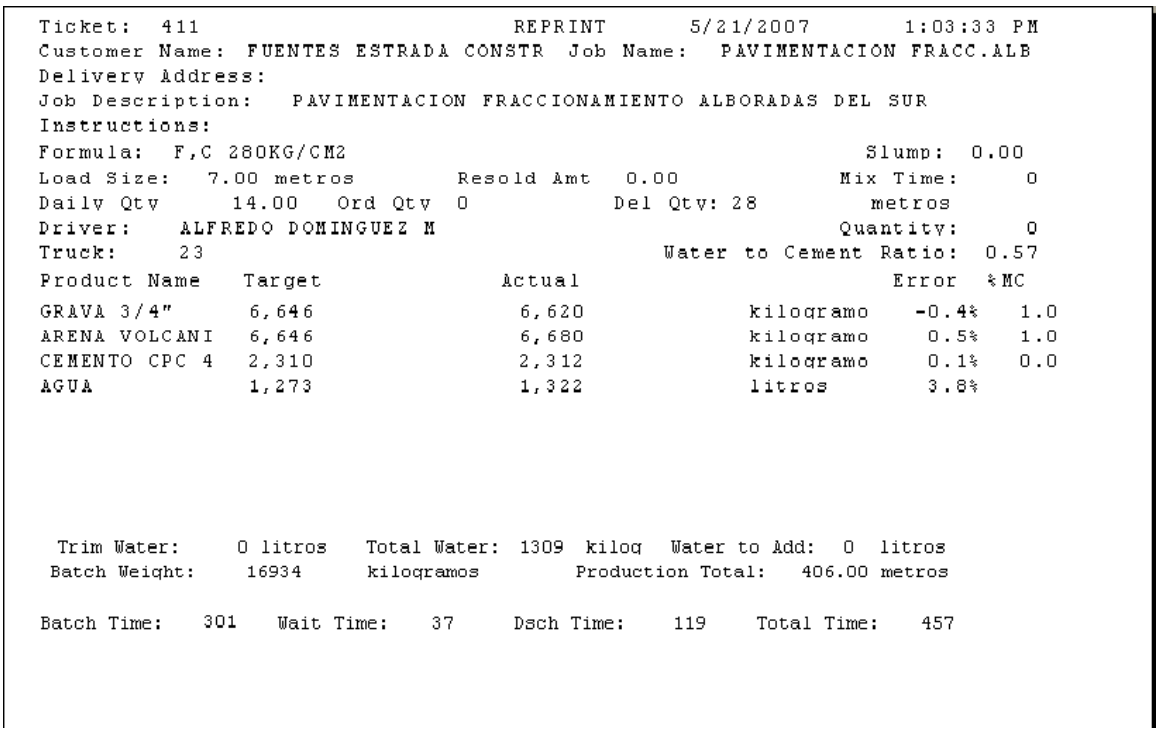
Signature: Chris Young
Title: EA1

Figure 13. Form SM 652 by INDOT

Review of Rexcon Ticket

As mentioned earlier, one of the two major software programs that are currently used by materials suppliers in the state of Indiana is RexCon, which has a capability to generate bar coded delivery tickets.

Currently, Rexcon has material producers manually input materials data into their system at the batch plant and generate paper tickets to be sent to the contractors and DOT. The data are stored in Microsoft Access database by the source and job and archived on a CD for future references. The data can be managed by using a web based application. Figure 14 is a sample ticket provided by Rexcon.



Ticket: 411 REPRINT 5/21/2007 1:03:33 PM
Customer Name: FUENTES ESTRADA CONSTR Job Name: PAVIMENTACION FRACC.ALB
Delivery Address:
Job Description: PAVIMENTACION FRACCIONAMIENTO ALBORADAS DEL SUR
Instructions:
Formula: F,C 280KG/CM2 Slump: 0.00
Load Size: 7.00 metros Resold Amt 0.00 Mix Time: 0
Daily Qty 14.00 Ord Qty 0 Del Qty: 28 metros
Driver: ALFREDO DOMINGUEZ M Quantity: 0
Truck: 23 Water to Cement Ratio: 0.57

Product Name	Target	Actual		Error	%MC
GRAVA 3/4"	6,646	6,620	kilogramo	-0.4%	1.0
ARENA VOLCANI	6,646	6,680	kilogramo	0.5%	1.0
CEMENTO CPC 4	2,310	2,312	kilogramo	0.1%	0.0
AGUA	1,273	1,322	litros	3.8%	

Trim Water: 0 litros Total Water: 1309 kilog Water to Add: 0 litros
Batch Weight: 16934 kilogramos Production Total: 406.00 metros

Batch Time: 301 Wait Time: 37 Dsch Time: 119 Total Time: 457

Figure 14. Sample Rexcon Ticket

System Configuration

System Overview

Table 1 shows a summary of the proposed automated materials delivery procedure. The data for material deliveries is transferred electronically so that it can be stored and processed. The material supplier transfers information from the scale houses to the truck. The trucking company delivers the material to the jobsite and hands the ticket to project personnel. The material supplier, trucking company, and contractor reconcile their material records. The benefits of this system are less time entering daily delivery tickets and electronic reconciliation of data and improved payment records.

Table 1. Proposed Automated Materials Delivery Procedure

Steps	Procedure Description
Step 1	Contractor orders material from material suppliers.
Step 2	Order is input into system, including material quantities and planned dates of delivery. Order is broken down into number of deliveries.
Step 3	A delivery ticket is printed for each individual delivery, including associated bar codes.
Step 4	Delivery truck arrives at location.
Step 5	Delivery truck driver hands the bar code labeled ticket to an inspector on site. The inspector accumulates tickets and scans them at a project trailer.
Step 6	Record of tickets scanned is sent to the material supplier for reconciliation.
Step 7	Material records for contractor, supplier, and owner are updated.

Figure 15 shows an automated materials delivery procedure proposed by this study. The shaded area in Figure 15 indicates the delivery process to be automated with bar codes. The material supplier will produce a bar code labeled ticket which will be used throughout the entire process including shipping confirmation and delivery. The material records are transferred to SiteManager. The paper records will be kept in the project documents file.

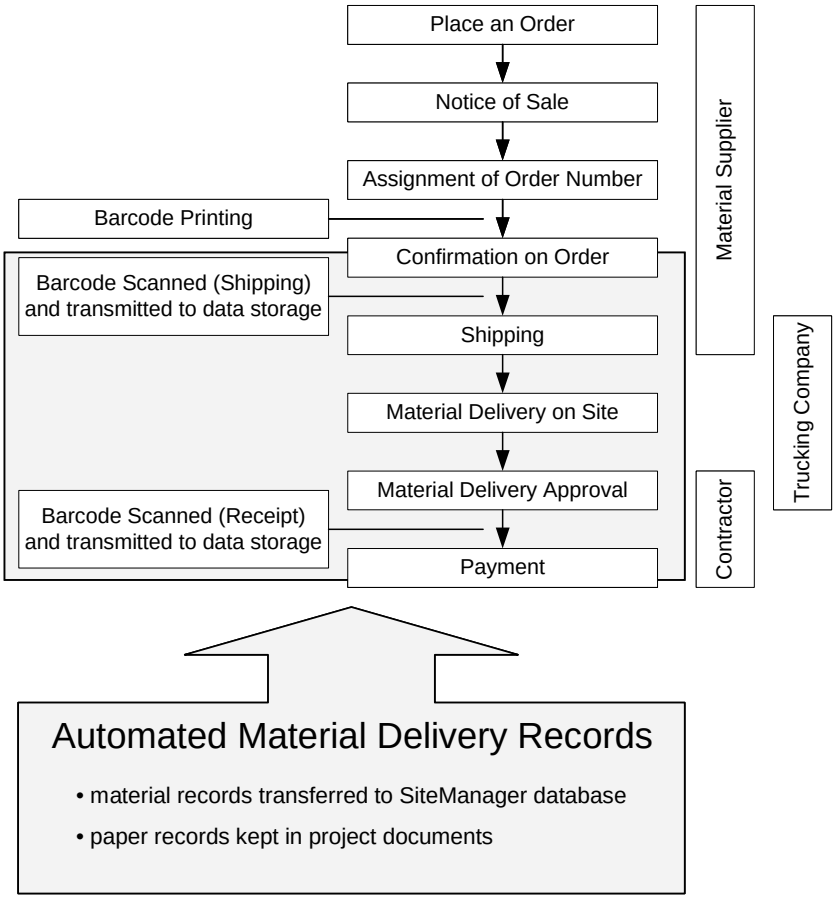


Figure 15. Automated materials Delivery Procedure

Prototype Ticket Using Bar Code

Typically delivery ticket information is introduced in an earlier section, but the project team created a prototype ticket only with some core information to be shown on a ticket. The following information is shown on the prototype ticket.

- Delivery Date
- Material Supplier Information
- Contract No.
- Material Information (Ticket No., Truck ID, Material ID, and Material Quantity)

The prototype ticket was tested using a pen-based bar code scanner. The testing uses a pocket PC to scan and process the data. The following is a simple three step procedure to scan and transfer data using the tested devices:

1. Scan bar codes in the ticket using a wireless scanner (Bluetooth)
2. Save the data into myfile.csv file in the Pocket PC
3. Transfer the scanned data to a remote server using a cellular network

Figure 16 shows a form developed by the project team to record the materials data on site using a pocket PC

Figure 16. Scan Form (Pocket PC Version)

The prototype ticket with bar codes used in the test is as shown in Figure 17. This system was demonstrated at the Super 70 INDOT project site for contractor and INDOT personnel. These personnel indicated a keen interest in using bar coded delivery tickets but that scanning would not be needed at the project site. Instead delivery tickets would be collected as currently done and the tickets scanned in the project office with a scanner attached to a desktop computer.

Material Delivery Ticket

Date: May 16 2007

Material Supplier Name: imi

Contract No.: IR28935

Material Information

Ticket No.		Ticket ID.		
1624048		47907 0001		
1624048		47907 0001		
Material ID		Quantity (ton)		
Product ID	Description	Gross	Tare	Net
4430	Stone	34.99	14.54	20.45
4430		34.99 14.54 20.45		

Figure 17. Prototype Delivery Ticket Using Bar Codes

Interface with SiteManager

During the last phase of the project, AASHTO SiteManager was studied to determine how the materials delivery data can be fed into the system. SiteManager is a construction management system developed by AASHTO. The system is basically an integrated collection of forms for information input and management from the contract award stage to file archival. The input data is stored in a database so that one can query project information archived in the database. There are six main modules in SiteManager including Contract Automation, Daily Work Reports, Contractor Payments, Change Orders, Civil Rights, and Materials Management. Down the road, SiteManager will integrate all various INDOT offices as well as contractors. The entire system is on line and available via the Internet.

The SiteManager software is Windows-based client/server architecture to be interoperable across various hardware platforms. The system uses Oracle database and is compatible to ODBC and OLE2 applications. On the user side, SiteManager resides on a client PC, which permits the user to input and query data stored in the database. Usually, project crew, inspectors, and area test lab staff will use SiteManager.

SiteManager is an integrated tool used for managing construction project data. It will primarily be used to track equipment and materials, record inspection data, track contractor progress and payments, and develop project reports. At the moment, SiteManager is not interfacing with other INDOT management applications. However, interfaces are possible with other applications for example, INDOT's operations management system called Agile Assets used for tracking field operation data.

One of the project objectives is to determine a way to feed on-site materials delivery data in to SiteManager. In fact, the State of Mississippi is currently using SiteManager to collect materials delivery data using a paper format ticket. In their system, a field engineer or administrative staff uses middle-ware to enter materials delivery information and electronically transfer the information to SiteManager. The middle-ware can be

programmed using PowerBuilder which is used for database manipulation. Based on the investigation of the State of Mississippi system and interview with INDOT SiteManager implementation staff, it is required to modify the middle ware to automate the entire process from automatically collecting materials delivery information on site to store the data in the SiteManager database. The following describes some considerations in developing the system to have this capability.

- Data Format in SiteManager:
  Comma/Tab Delimitated Text or MS Excel table formats

- Data Transmission Options:
  Copy data in a common place on the network and transfer data to SiteManager database on a regular basis either automatically or manually

- SiteManager Server Location:
  Indiana Department of Transportation

- Data Storage:
  All the following data will be stored in Daily Work Report module.
  - Delivery Data
  - Material Supplier ID
  - Truck ID
  - Contract No.
  - Job No.
  - Ticket No.
  - Source Code
  - Material ID
  - Material Quantity

Daily Work Report template can be used to manually enter the above data into the system. The template can take the raw data and automatically calculate pay quantity to be stored

in the system. There are three options to automate the data input process suggested by INDOT staff. One option is VB.net to script database query functionality. The second is Power Builder to import the scanned ticket as a text file. The last is writing an executable program. The typical development time for the executable program will be some where from 4 weeks to 7 weeks including testing.

Actual cost involved in the software development for SiteManager application was not studied during this study.

Development Costs

Development costs data for bar code systems and options are summarized in Table 2. This study tested Option 3 with Pocket PC and a wireless bar code scanner to record material delivery data.

Table 2. Comparison of Equipment Options and Costs

	Option 1	Option 2	Option 3	Option 4
Data Collection and Transmission	Pocket PC	Desktop PC	Pocket PC	Symbol MC50
Scanner	USB Scanner	Laser Scanner	Wireless Scanner	-
Adapter	Type B – A	NONE	-	-
Total Cost Estimates	$405	$100	$450	$1000

Detail Models and Costs

Cingular Smart Phone (Cingular 8125 Pocket PC):	$250
PDA (Symbol MC5040 – PK0DBQEA7WR):	$1000
USB Scanner (Metrologic MS9520 Voyager):	$152
2D Barcode Scanner (Metrologic MS1690 Focus):	$354
Wireless Scanner (Baracoda Pencil 2):	$200
Adapter (Type B male – Type A female):	$3

Option 2 is the most economical and preferred by INDOT. In this option a laser scanner is added to the desktop PC. Tickets are collected and material delivery data scanned daily by INDOT field personnel.

The detailed development cost for bar code labeling software to be used to create tickets was not studied during this project. However, according to one of the software vendors, the minimum development cost may be around $1,000.

Conclusions

The objectives of this synthesis study were to propose a process to electronically transfer materials information between material suppliers, trucking companies, project personnel and contractor; collect information on similar applications; and recommend options to consider for automating material delivery for highway construction projects.

To meet the objectives, the project conducted numerous meetings with stakeholders that include INDOT materials and test staff, pavement and aggregate business sectors, and material producers. Also, two surveys were conducted in an effort to collect inputs from other state transportation agencies and material producers. These two surveys served to provide the project team with new trends and technologies in materials industry, current systems used in other states, and their willingness to and resistance against the INDOT's effort to automate materials delivery records. Detailed results can be found in the report.

This project investigated current technologies developed in the automatic identification industry and provided many options and concerns toward the development of automatic materials delivery system in INDOT. As described earlier in the report, this project identified the following options to be considered to develop automated materials delivery records. Apparently, depending on the options chosen, cost and methods for actual development may vary due to the variance of required hardware and software.

Symbology Options

- One dimensional bar code
- Two dimensional bar codes

Bar Code Scanner Options

- USB Linear Bar Code Scanner
- 2D Bar Code Scanner
- Wireless Scanner with Bluetooth
- PDA with bar code imager

Bar Code Printer Options

- Direct Thermal Printer
- Thermal Transfer Printer
- Common ink-jet or laser-jet printer

Bar Code Printing Software Options

- Free software provided by hardware manufacturers
- Commercial bar code printing software
- Web application that generates bar coded documents that are printable

Data Transfer Options

- Scan the materials data on site and transfer it to INDOT project management server such as SiteManager later in time
- Collect bar code tickets and scan them in the field office and transfer the scanned data later in time
- Scan and transfer data in real time

SiteManager Data Input Options

- VB.net to script database query functionality
- Power Builder to import the scanned ticket as a text file
- An executable program

With many valuable inputs from the Study Advisory Committee, this project performed the study from many different angles in an effort to determine what options are available for future system development. One possibility, the automated materials delivery records system will potentially be beneficial to all the project parties from material suppliers, trucking companies, contractors to the state. Using bar codes on delivery tickets is acceptable to the majority of INDOT stakeholders. However there is resistance from some aggregate suppliers. It is recommended that delivery tickets have bar code symbols for certain fields. These fields must be agreed upon by a joint committee of INDOT,

contractor, and material suppliers. Because some suppliers will not be able to produce these types of delivery tickets, a paper based ticket will continue to be accepted. However, by establishing some guidelines and encouraging bar coded delivery tickets, an automated delivery process for materials can be initiated.

The above bar code system requires additional hardware (scanners) and software(e.g. label printing) which will have resistance from current parties involved in materials. another option is for INDOT to develop an on-line system. This system would consist of:

- material supplier interface
- material receipt interface
- material tracking interface
- barcodes are optional

The on-line system would be a web site. This system would be similar to what delivery companies (FedEx, UPS, DHL) use. The material supplier would enter their information when material is sent to an INDOT project or site. It will be tracked by a unique identifier code associated with that delivery. A delivery ticket would be sent with the material and it could contain an identifier bar code but not necessarily.

When the material is delivered then the receipt interface would allow the receiver to enter the identifier code and record its delivery. The tracking interface provides information on material status, whether it has been received, where used, approved for payment, or reasons for rejection.

This option would be easier and more economical to interface into the current methodology. Both of these options would require endorsement and support from BITS. Interfaces into SiteManager and Agile Assets would be features of either option.

This study has found interest and cooperation from the various parties involved in providing materials to INDOT. Some of the aggregate producers will not support the bar

code option due to its cost. However there is interest among HMA and concrete suppliers. Based on this finding INDOT should take the next step and move forward utilizing methods described in this report. JTRP and Research can serve as a mechanism to move this forward through the next phase of Implementation.

References

AASHTO “AASHTOware Trns*port” Available Online: http://aashtoware.org/?siteid=28&pageid=73

Association for Automatic Identification and Mobility “Automatic Identification and data capture (AIDC)”, Available Online: http://www.aimglobal.org/technologies/wwwhwofaidc.pdf

Bob G. McCullouch (1997) “Automating Field Data Collection in Construction Organizations”, Construction Congress V: Managing Engineered Construction in Expanding Global Markets pp 957-963

Bob G. McCullouch (2000) “Construction Data Management 2000”, Joint Transportation Research Program Final Report

Connecticut Department of Transportation Bureau of Engineering and Highway Operations “Project Manager Basic Manual for SiteManager” Available Online: http://www.conndot.ct.gov/construction/xAppendix%20A-SiteManager%20Project%20Inspection%20Manual.pdf

Info Tech Cloverleaf “SiteManager Module Overview (Flash Movie)” Available Online: https://www.cloverleaf.net/index.php?option=com_docman&task=doc_view&gid=332

Appendices

Appendix A. State Transportation Agencies Survey Questions

Does your Agency have an automated material delivery tracking system for transportation construction projects?

If "No", proceed to Question 9.

Please describe the system components of your material delivery tracking system.

- Field Components
- Office Components

If your system utilizes bar codes or other types of automatic identification technologies, please describe the system components and technology being used.

What are the beneficial factors from using your automated material delivery tracking system? Please evaluate the followings.

- Ease in data logging/record keeping
- Communication between project entities
- Reconciliation of material records
- Data accuracy
- Compatibility to project management system

With regard to the method being used in your State, please describe the challenges or limitations which could be the most problematic.

What are the disadvantages of your automated material delivery system?

Does your Agency have a training program for this system?

In what format, does your Agency implement the training program?

- On-line training
- On-the-job training
- Traditional classroom-based training
- Others

Is there a strong need to develop an automated material delivery tracking system on construction projects?

Would you like to receive a copy of the result of this survey?

May we contact you to collect more information about your material delivery tracking system?

Appendix B. Aggregate Producers Survey Questions

Does your company use any software for materials tracking?

__ Yes __ No

Is your software an in-house application or a commercial one?

__ In-House __ Commercial

If you currently use commercial software, please provide us with software name.

Please describe the main features of your software.

Do you use the aforesaid software to generate a delivery ticket?

__ Yes __ No, we use _____

What information is included in your ticket?

May we contact you to collect more information about your software?

Appendix C. SAC Meeting Minutes

There were two SAC meetings held in February and May, 2007.

SAC Meeting #1

Date: February 23, 2007
Attendance:

Krystal Cornett	INDOT Division of Highway Operations
Brandon Stevens	INDOT Research and Development
Raette Wilson	INDOT Office of Materials Management
Bob McCullouch	Purdue
Jay Lee	Purdue

	Issues/Questions	Comments/Answers	Suggestions/Remarks
1	Do we consider developing interface with SiteManager?	No. We need to have our data compatible with SiteManager, but we don't develop the interface with SiteManager.	SiteManager contact is Deb Hood.
2	When do they get SiteManager up and running?	July, 2007	
3	Are we considering the interface with Agile Asset and People Soft?	We are focusing on interfacing with SiteManager in this study. INDOT is expressing a desire to use this approach with maintenance materials.	Derrick Edward and Lynett Gorczyca are the contacts for Agile Assets.
4	Does SiteManager have financial functionality?	No. SiteManager is used for construction records. Accounting features and needs are performed in People Soft.	
5	How does INDOT reconcile the data in the current accounting system?	Krystal will find out who we will need to contact.	Brandon suggests that we visit some sites to get aware of environment on the sites and see how they track materials delivery data.
6	State Transportation Agencies will be contacted to determine if they have any automated systems for material delivery		Brandon will provide a list of contacts in the State Transportation Departments

	Issues/Questions	Comments/Answers	Suggestions/Remarks
7	How do we collect information from material suppliers and trucking companies?		Contact major contractors and material suppliers, for example, Rieth Riley, IMI, Purdy, etc.
8	Can we get some samples of tickets?	Krystal will provide them. We need to develop a prototype ticket to be used for this approach (delivery ticket + barcode).	
9	Investigating other industries that automate material delivery.		Collect case studies on Symbol and other manufacturers of bar coding scanning equipment.
10	Develop a conceptual plan that includes answers on hardware and software requirements.		This will be presented at the next SAC meeting.
11	How can we deal with the other construction materials other than bulk materials?	We need to have a list of materials going into SiteManager and see how we can deal with them.	Raette will provide the list.

What to do next

- Develop a questionnaire to be distributed to other state agencies.
- Collect case studies from Symbol and other scanning manufactures on similar applications.
- Determine how a smart phone can be programmed to collect delivery ticket data.
- Determine how bar codes can be added to a delivery ticket.
- Check out what printing software is needed.

SAC Meeting #2

Date: May 30, 2007
Attendance:

Brandon Stevens	INDOT Research and Development
Raette Wilson	INDOT Office of Materials Management
Mark Miller	INDOT Division of Construction Management
Mike Byers	INDOT ACPA
Tony DeSimone	FHWA
Bob McCullouch	Purdue
Jay Lee	Purdue
Michelle Leung	Purdue

	Issues/Questions	Comments/Answers	Suggestions/Remarks
1	Need to meet with ACPA people to see if they are for/against this approach and get inputs from them to improve the method.	An ACPA meeting on June 20th at 9:30 am at the Materials and Test office	Mike Byers and Mark Miller will arrange the meeting and put it on the agenda.
2	When will we visit a site to observe how they handle material delivery data and where?	In the earlier morning before June 20th ACPA meeting	Mike Byers suggested to visit a site around I70 and 267 near the airport.
3	Do the suppliers have to access our website to generate their ticket?	Yes, although they may have their own accounting system to create their tickets, they will have to take one more step to generate another ticket with bar codes embedded to be used for this approach.	Mark Miller expressed concerns about resistance on the supplier side against spending extra time to do so. We need to put this on the table in June 20th meeting and see what they say.
4	What benefits do we expect from using this approach?	Brandon Stevens mentioned some potential benefits such as measuring delivery time by time stamping, less risk of data input error, timely payment, ease of reconciliation, and simplified data input, etc.	
5	How will the suppliers get paid?	Mike Buyers expressed some concerns and confusion with regard to individual material payment and batch payment.	We also need to find out how to deal with this by visiting the site and speaking with some people out there.

	Issues/Questions	Comments/Answers	Suggestions/Remarks
6	Are we going to scan the bar codes at the site or in the office?	Mark Miller prefers to scan bar codes as they come.	
7	How do we deal with specialized materials such as guardrails?		We need to discuss this at the ACPA meeting.

Work Progress as of May 30

	Tasks	Status
1	Survey State Transportation Agencies	Done
2	Determine how a smart phone can be programmed to collect delivery ticket data.	Done
3	Determine how bar codes can be added to a delivery ticket.	Done
4	Check out what printing software is needed.	Done
5	Collect information from material suppliers on similar applications	Done

What to do next

	Tasks	Status
1	Investigate other industries using automated delivery tracking system	On going
2	Contact Deb Hood for SiteManager.	
3	Contact Derrick Edward and Lynette Gorczyca for Agile Assets and People Soft.	
4	Find a site to observe how they track materials data.	June 20th
5	Find out how to deal with materials data going into SiteManager.	

Appendix D. Other Meetings

Meeting with Concrete Paving Contractors

Date: June 20, 2007
Venue: INDOT/PCCP Technical Committee Meeting at Materials and Tests Office
Host:
Mike Byers INDOT ACPA
Ron Walker INDOT Materials and Tests Division

The meeting consisted of a presentation on the project objectives and the use of bar codes on material delivery tickets. After the presentation a discussion occurred and these are the issues discussed.

1. Any inputs from ACPA people about bar code embedded ticket?

   Materials are treated in different ways in measurement. For example, concrete pavement is measured in square yards, curbs and barriers use linear feet. Also, as far as payment, in some cases materials are not paid separately but included in the entire structure. This is a concern to generate a prototype ticket with bar codes because materials on site are handled differently.

2. Investigate how suppliers get paid. Would it be individual material payment or batch payment?

   Someone made a suggestion that we consider an ability to split the ticket so that different materials can be treated.

3. Do the suppliers have to generate tickets although they have their own accounting systems?

   There is not much resistance identified on this. Some at E&B Paving expressed positive opinions on that because one more step of generating bar code embedded ticket will save much of their time in handling materials data afterwards. This is a software issue and E&B uses Rexcon software. Apparently there are two kinds of software used by material suppliers in Indiana, Rexcon and Alkon. Ron Zink provided the contact info for Rexcon software.

4. How do we deal with specialized materials such as guardrails, fences, etc.?

   This area of material, lesser in quantity, still needs to be included when developing an automated system for material delivery.

5. There will be a meeting with Aggregate suppliers on July 13 at Materials and Test.

Tour of Concrete Batch Plant and Site – Super 70 Project

Date: June 20, 2007
Venue: E & B Paving, Indianapolis (Contact: Ron Zink)
Attendance:
Neil Douglass E&B Paving
Monti Mason – INDOT
Dan Stribe – INDOT
Chris Young - INDOT

Issues

1. Look at the site to get aware of environment on the site. Observe how they handle materials data on site and see how they track materials delivery data.

   E&B Paving explained how they handle their materials. There are two forms used by E&B Paving: one for material information and the other for INDOT record. E&B Paving is favorable about the use of bar codes on delivery tickets, but they want to make it simple.

   After describing a potential system, E&B Paving and INDOT felt like that a scanner at the project office would save time and improve data entry. Both say that a scanner at the project is not needed.

   Ron Zink gave us some contacts so that we can ask more about how the suppliers handle materials data and how they automate printing their tickets. The following is their contacts.

   Jeff Soldan at RexCon (Programmer)
   jeffsoldan@earthlink.net

   Jon Havens at IMI (QA/QC)
   Jon.havens@irvmat.com
   317-402-1900

2. Find out how they deal with specialized construction materials other than bulk materials (e.g. guardrails, fences, etc.).

   E&B Paving only handles bulk materials.

3. Find out how they currently enter materials data into SiteManager.

   The SiteManager is not currently being used. INDOT will begin to use the SiteManager in July.

4. Seek other inputs from their perspectives regarding materials data handling on site (e.g. any room for improvement, complaints, etc.)

   E&B Paving wants to include the information about the sources of materials in the ticket for accounting purpose. Materials will therefore be sorted by the job code and the source code.

Meeting with Aggregate Contractors

Date: July 13, 2007
Venue: INDOT/ IMSS Technical Committee Meeting at Materials and Tests Office
Host: Ron Walker, INDOT Materials and Tests Division

The meeting consisted of a presentation on the project objectives and the use of bar codes on material delivery tickets. After the presentation a discussion occurred and these are the issues discussed.

Contact Raba-Kistner Consulting Inc. in Texas

They have an Information Transfer System used for material tracking. Robert Jones has username and password for the software.

Command Alkon has in-house software/ticketing application developed by JWS. JWS is a part of Command Alkon.

Martin Marietta Aggregates uses bar codes in the ticket (Remote Kiosk).

What kind of printer is needed for bar code labeling?

They should use ink jet or laser printer for bar code application.

Any challenges?

Cost for software conversion in order to have bar code reading capability. It must be costly to switch an old ticket application to a bar code ticket one.

What information needs to include in the ticket?

Source Number and Name, Queue Number (both bar code and text description)
Aggregate Size, Register for the stone
Running Total for the specific job
Type of Mix for different contracts and different locations

Figure out what type of software used by aggregate producers.

A survey is needed to see what they have. Robert Jones will help distribute the survey questionnaire to their members. Ask Mike Byers to survey the concrete producers, too.

Any other benefits?

Identification of the origin of the materials, speedy payment, and less errors in recording